CLAIMS

1. A pressure vessel, comprising:

an inner shell capable of serving as a gas barrier and a pressure resistant outer shell provided to cover the inner shell, which said outer shell is made of an FRP comprising reinforcing fibers and a resin and of 35 GPa or more in tensile modulus and 1.5% or more in tensile breaking strain.

2. A pressure vessel of claim 1 characterised in that the inner shell is made of a metal, resin or FRP.

3. A pressure vessel of claim 1 characterised in that the inner shell has a gas barrier layer formed on the inside surface and/or outside surface.

4. A pressure vessel of claim 1 characterised in that the inner shell has a body portion, on which a reinforcing layer made of an FRP is formed.

5. A pressure vessel of claim 1 characterised in that the outer shell is 35 GPa or more in tensile modulus and 1.7% or more in tensile breaking strain.

6. A pressure vessel of claim 1 characterised in that the outer shell is 35 GPa or more in tensile modulus and 2.0% or more in tensile breaking strain.

7. A pressure vessel of claim 1 characterised in that the reinforcing fibers comprise carbon fiber yarns of 4.5 GPa or more in strand tensile strength and 2.0% or more in strand tensile breaking strain.

8. A pressure vessel of claim 1 characterised in that the reinforcing fibers comprise carbon fiber yarns of 5.5 GPa or more in strand tensile strength and 2.0% or more in strand tensile breaking strain.

9. A pressure vessel of claim 7 ~~or 8~~ characterised in that the reinforcing fibers comprise carbon fiber yarns of 0.30 or less in oxygen ratio at surface and 0.02 or more in nitrogen ratio at surface.

10. A pressure vessel of claim 1, ~~5 or 6~~ characterised in that the outer shell comprises a layer of reinforcing fibers arranged, with reference to the axial direction

of the pressure vessel, at an angle within a range from ±5° to ±50° and a layer of reinforcing fibers arranged at an angle within a range from ±75° to ±105°.

11. A pressure vessel of claim 1, ~~5 or 6~~ characterised in that the outer shell comprises a layer of reinforcing fibers arranged, with reference to the axial direction of the pressure vessel, at an angle within a range from ±0° to 15°, a layer of reinforcing fibers arranged at an angle within a range from ±75° to ±105° and a layer of reinforcing fibers arranged at an angle within a range from ±30° to ±60°.

12. A pressure vessel of claim 10 characterised in that the volume ratio of reinforcing fibers in the layers of reinforcing fibers arranged, with reference to the axial direction of the pressure vessel, at an angle within a range from ±5° to ±50° : that in the layer of reinforcing fibers arranged at an angle within a range from ±75° to ±105° is in the range of 1.0 : 1.0-2.0.

13. A pressure vessel of claim 11 characterised in that the volume ratio of reinforcing fibers in the layers of reinforcing fibers arranged, with reference to the axial direction of the pressure vessel, at an angle within a range from ±0° to 15° : that in the layer of reinforcing fibers arranged at an angle within a range from ±75° to ±105° : that in the layer of reinforcing fibers arranged at an angle within a range from ±30° to ±60° is in the range of 1 : 1.5-2.5 : 0.2-1.2.

14. A process for producing a pressure vessel characterised in forming, by a filament winding method or a tape winding method, a pressure resistant outer shell, around an inner shell capable of serving as a gas barrier, said outer shell is made of an FRP comprising reinforcing fibers and a resin and is 35 GPa or more in tensile modulus and 1.5% or more in tensile breaking strain.

15. A process for producing a pressure vessel of claim 14 characterised in that the outside surface of the inner shell is roughened, prior to the filament winding method or the tape winding method.

16. A process for producing a pressure vessel of claim 14 characterised in that the outer shell comprises a layer of reinforcing fibers arranged, with reference to

the axial direction of the pressure vessel, at an angle within a range from ±5° to ±50° and a layer of reinforcing fibers arranged at an angle within a range from ±75° to ±105°.

17. A process for producing a pressure vessel of claim 14 characterised in that the outer shell comprises a layer of reinforcing fibers arranged, with reference to the axial direction of the pressure vessel, at an angle within a range from ±0° to ±15°, a layer of reinforcing fibers arranged at an angle within a range from ±75° to ±105° and a layer of reinforcing fibers arranged at an angle within a range from ±30° to ±60°.

18. A process for producing a pressure vessel of claim 16 characterised in that the volume ratio of reinforcing fibers in the layer of reinforcing fibers arranged, with reference to the axial direction of the pressure vessel, at an angle within a range from ±5° to ±50° to that in the layer of reinforcing fibers arranged at an angle within a range from ±75° to ±105° is in the range of 1.0 to 1.0-2.0.

19. A process for producing a pressure vessel of claim 17 characterised in that the volume ratio of reinforcing fibers in the layer of reinforcing fibers arranged at an angle within a range from ±0° to ±15° to that in the layer of reinforcing fibers arranged at an angle within a range from ±75° to ±105° to that in the layer of reinforcing fibers arranged at an angle within a range from ±30° to ±60°, with reference to the axial direction of the pressure vessel, is within a range of 1 to 1.5-2.5 to 0.2-1.2.

20. A process for producing a pressure vessel of claim 14 characterised in forming a pressure resistant outer shell having a tensile modulus of 35 GPa or more and a tensile breaking strain of 1.7% or more.

21. A process for producing a pressure vessel of claim 14 characterised in forming the pressure resistant outer shell having a tensile modulus of 35 GPa or more and a tensile breaking strain of 2.0% or more.

22. A process for producing a pressure vessel of claim 14 characterised in using as the reinforcing fibers carbon fiber yarns of 4.5 GPa or more in strand tensile strength and 2.0% or more in strand tensile breaking strain.

23. A process for producing a pressure vessel of claim 14 characterised in using as the reinforcing fibers carbon fiber yarns of 5.5 GPa or more in strand tensile strength and 2.0% or more in strand tensile breaking strain.

24. A pressure vessel of claim 1 characterised in that the pressure vessel has a body portion, and the outer shell has a layer structure of 5 or more layers around the body portion, the relation between the total thickness T (mm) of all the layers and the number N of the layers, satisfying $0.5 \leq T/N \leq 6$.

25. A pressure vessel of claim 24 characterised in that, in said body portion, layers with reinforcing fibers hoop-wound and layers with reinforcing fibers helically wound are alternately arranged in the thickness direction of the outer shell.

26. A process for producing a pressure vessel of claim 14 characterised in that the outer shell is formed to have a layer structure of 5 or more layers around the body portion of the inner shell, and the relation between the total thickness T (mm) of all the layers and the number N of the layers satisfies $0.5 \leq T/N \leq 6$.

27. A process for producing a pressure vessel of claim 26 characterised in that layers with reinforcing fibers hoop-wound and layers with reinforcing fiber helically wound are alternately arranged in the thickness direction of the outer shell.

28. A process for producing a pressure vessel of claim 26 characterised in that a non-twisted reinforcing fiber bundle having a ratio D/t of 5 or more is used as the reinforcing fibers, where D is the width of the bundle not yet impregnated with any resin and t is the thickness of the bundle.

29. A pressure vessel of claim 1 characterised in that the outer shell comprises the following components [X], [Y] and [Z], and the component [Z] is localized around the component [X] appearing in a cross sectional face of the outer shell:

[X] : a reinforcing fiber bundle

[Y] : a thermosetting resin

[Z] : an elastomer and/or thermoplastic resin.

30. A pressure vessel of claim 29 characterised in that the ratio L_2/L_1 satisfies $1/100 \leq L_2/L_1 \leq 1/2$, where L_1 is the length of a straight line connecting the geometrical centers of two adjacent component [X], L_2 is the length of a portion of the straight line crossing the component [Z] present between the said two adjacent component [X].

31. A pressure vessel of claim 29 characterised in that the component [Z] comprises at least one selected from the group consisting of polyvinyl acetate, polyamides, polycarbonates, polyacetals, polyphenylene oxide, polyphenylene sulfide, polyallylates, polyesters, polyamidimides, polyimides, polyether imides, polysulfones, polyether sulfones, polyether ether ketone, polyaramid, polybenzimidazole, polyethylene, polypropylene, cellulose acetate, cellulose butyrate, polyester based thermoplastic elastomers and polyamide based thermoplastic elastomers.

32. A process for producing a pressure vessel of claim 14 characterised in that the pressure resistant outer shell is formed by using a yarn prepreg which comprises the following components [X], [Y] and [Z], which component [X] is impregnated with the component [Y], and which component [Z] is present near the surfaces:

[X] : a reinforcing fiber bundle

[Y] : a thermosetting resin

[Z] : an elastomer and/or thermoplastic resin.

33. A process for producing a pressure vessel of claim 32 characterised in that the yarn prepreg used has particles of the component [Z] deposited on the surfaces of the component [X] impregnated with the component [Y].

34. A pressure vessel of claim 1 characterised in that the outer shell comprises a shoulder portion, and the innermost layer of the shoulder portion comprises a layer with reinforcing fibers hoop-wound.

35. A pressure vessel of claim 34 characterised in that the innermost layer is formed by the filament winding method.

36. A pressure vessel of claim 34 characterised in that the circumferential surfaces of the shoulder portion of the inner shell are formed to have steps in the axial direction, respectively extending in the circumferential direction.

37. A process for producing a pressure vessel of claim 14, which comprises providing a reinforcing layer of reinforcing fibers having a hoop-wound layer of reinforcing fibers and a resin, on the circumferential surface of the shoulder portion of the inner shell which has a body portion and a shoulder portion, and forming the pressure resistant outer shell around the reinforcing layer and the inner shell.

38. A process for producing a pressure vessel of claim 37 characterised in that the reinforcing layer is formed by the filament winding method.

39. A process for producing a pressure vessel of claim 37 characterised in that the reinforcing layer is formed by the filament winding method as an extended layer of the innermost layer of the outer shell formed on the circumferential surface of the body portion of the inner shell.

40. A pressure vessel of claim 1 characterised in that the inner shell comprises a neck portion, inside which a boss for nozzle installation is provided, and a seal ring is fitted on the end face of the neck portion around the boss for nozzle installation, and a pressing means is provided for pressing the seal ring toward the end face of the neck portion.

41. A pressure vessel of claim 40 characterised in that the pressing means comprises a seal ring pressing member and a clamp of the pressing member.

42. A pressure vessel of claim 40 characterised in that the pressing means comprises a pressing member threadedly engaged with the boss for nozzle installation.

43. A pressure vessel of claim 40 characterised in that the pressing means comprises a pressing member comprising a cylindrical portion threadedly engaged with the neck portion, and a collar portion held in contact with the seal ring.

44. A pressure vessel of claim 40 characterised in that the boss for nozzle installation comprises a flange portion, and the outer diameter of the pressing means is smaller than the outer diameter of the flange portion by 1 to 10 mm.

45. A pressure vessel of claim 40 characterised in that the end face of the neck portion comprises an annular groove provided to have the seal ring fitted therein.

46. A pressure vessel of claim 42 characterised in that the outer shell extends up to a position to cover the pressing member.

47. A pressure vessel of claim 43 characterised in that the cylindrical portion comprises a step.

48. A pressure vessel of claim 1 characterised in that the inner shell comprises a neck portion; a boss for nozzle installation is provided inside the neck portion; and the surface of the boss for nozzle installation to be coupled with the neck portion has a rugged form.

49. A pressure vessel of claim 1 characterised in that the inner shell comprises a neck portion; inside which a boss for nozzle installation is provided, and the surface of the boss for nozzle installation to be coupled with the neck portion has a circumferentially extending ridge.

50. A pressure vessel of claim 49 characterised in that additionally the surface to be coupled has a rugged form.

51. The pressure vessel of claim 48 ~~or 49~~ characterised in that a seal ring is fitted on the end face of the neck portion around the boss for nozzle installation, and a means for pressing the seal ring toward the end face of the neck portion is provided.

52. A pressure vessel of claim 1 characterised in that the inner shell comprises a neck portion inside which a boss for nozzle installation is provided, and outside the neck portion a cylindrical member having a collar portion, a cylindrical portion in succession to the collar portion and a flange portion extending from the circumferential surface of the cylindrical portion into the outer shell are provided.

53. A pressure vessel of claim 52 characterised in that the flange portion extends annularly.

54. A pressure vessel of claim 52 characterised in that a seal ring is fitted on the end face of the neck portion around the boss for nozzle installation, and the collar portion presses the seal ring toward the end face of the neck portion.

55. A pressure vessel of claim 52 characterised in that a clamp of the cylindrical member, threadedly engaged with the boss for nozzle installation is provided outside the collar portion of the cylindrical member.

56. A pressure vessel of claim 52 characterised in that the collar portion is threadedly engaged with the boss for nozzle installation.

57. A pressure vessel of claim 1 characterised in that the inner shell has a neck portion inside which a boss for nozzle installation having a flange portion and a body portion is provided and the outer diameter of the flange portion is larger than the outer diameter of the body portion by 20 mm to 25 mm, and the cylindrical portion has a tapered surface kept in contact with the neck portion.